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University of Kentucky

CALCIUM METABOLISM IN THE LAYING HEN. II.

BULLETIN NO. 252.

(Research Bulletin)

Lexington, Ky.

March, 1924

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SUMMARY.

1. The hens receiving limestone produced larger eggs than those that did not receive it, and the hens receiving corn, buttermilk and limestone produced larger eggs than those receiving corn, mash containing tankage, and limestone, both the eggshell and the liquid part being heavier.

2. Calcium carbonate (limestone) greatly increased the efficiency of buttermilk for egg production.

3. Deficiency of calcium in the diet does not materially change the calcium content of the liquid portion of eggs but it materially decreases the number of eggs laid and the production of eggshell.

4. Deficiency of calcium in a diet abounding in protein, is not a primary cause of shell-less (soft shell) eggs.

5. Adding calcium carbonate (limestone) to a corn-buttermilk diet increased the weight of the eggshells nearly 40 per cent in one month, whereas withholding calcium carbonate from hens that had been receiving it with corn and buttermilk caused a decrease of about 20 per cent, in the same time.

6. When a supplement of calcium carbonate (limestone) is allowed *ad libitum*, the average weight of an eggshell is approximately the same, whether the source of animal protein in the diet is buttermilk or tankage.

7. The percentages of CaO and P_2O_5 in the leg-bones are diminished materially by calcium deficiency in the diet.

8. The addition of calcium carbonate (limestone) to a buttermilk corn ration did not cause as large a deposition of mineral matter in the leg-bones as when it was fed in connection with a tankage-corn ration.

9. The hens receiving buttermilk and corn were in notably better condition at all times than those receiving corn and a mash containing tankage, without buttermilk.

10. Deficiency of calcium in the diet causes a general depletion of the body material and general vigor of the hens.

11. Under the conditions of this experiment, hens receiving buttermilk as a source of protein produced more eggs and laid over a longer time than those receiving the corn-tankage mash, without buttermilk.

12. A diet of corn and buttermilk does not supply enough calcium for satisfactory egg production and a diet of corn and mash, containing tankage, tho containing more calcium than the corn-buttermilk

ration, is even less efficient. Both must be supplemented liberally with calcium carbonate.

13. The body balance of a laying hen is not maintained on a corn-buttermilk diet, in the absence of a calcareous supplement, nor is egg production satisfactory.

14. The body balance of the hens in this experiment seemed to be maintained on a diet of corn and a mash containing tankage, without a calcareous supplement, but egg production was not satisfactory.

15. The practical conclusion for the poultryman is that, for satisfactory egg production, laying hens on a diet of corn and buttermilk or corn and a dry mash containing tankage, must be given additional calcium, which should be in the form of carbonate (high-grade, nonmagnesian limestone or oyster shell).

BULLETIN NO. 252

(Research Bulletin)

Calcium Metabolism in the Laying Hen. II.*

By G. DAVIS BUCKNER, J. HOLMES MARTIN and A. M. PETER

The object of the experiment described herein was to obtain information concerning the following points:

1. Do simple, common foods such as corn and buttermilk or corn and tankage, supply sufficient calcium for normal egg production and also to maintain the normal body balance of the laying hen? If not, to what extent must calcium be supplied from other sources

2. Does the calcium intake of a hen during the laying season materially affect the weight of the edible portion of her eggs as well as the weight of the shells?

3. Do buttermilk and tankage, when these materials are fed *ad libitum,* properly and equally supplement corn? To what extent do they affect egg production and the weight of the edible part of the egg?

4. Can shell-less (soft shelled) eggs be produced by limiting the calcium intake while supplying an abundance of efficient protein?

THE EXPERIMENT

Four lots of birds were used, each containing 10 Single Comb White Leghorn pullets, coming from the same parent stock and hatched in an incubator the same day, April 8, 1921. They had been raised under the same normal conditions, had received the same food, limestone, charcoal and grit, and had been allowed free access to a large meadow range. On November 1, 1921, each lot of pullets was put into an 8′x10′ henhouse and not allowed to run in the yard, thus eliminating any possibility of

*Part I was published as Research Bulletin 250 of this Station, Calcium Metabolism in the Laying Hen, Lexington, Ky., October, 1923.

their obtaining calcium or protein from sources other than the foods given them. The foods used consisted of the materials named in Tables 1 and 2.

System of Feeding. The experiment was started November 1, 1921, and continued for 7 monthly periods of 30 days, using the rations indicated in Table 1; at the expiration of that time, May 30, 1922, the rations were changed, as indicated in Table 2, and observations were continued with some of the hens in June and July.

The grain fed thruout the experiment was shelled yellow corn which was thrown into the straw litter in the morning and evening. A light feeding was given in the morning but in the evening the birds were given all they would readily consume. The straw litter was changed frequently. Fresh, clean buttermilk which had been neutralized with lime* by the producer was obtained daily from a creamery and was before the hens of lots 1 and 2 at all times during the first 7 months.

The mash used was a mixture of 1 part of tankage and 4 parts of ground yellow corn, by weight. It was before lots 3 and 4 at all times during the first 7 months. No grit was supplied to any pen,** and no water was allowed the hens that received buttermilk, in order that they might be made to consume as much buttermilk as possible.

On May 30, 1922, the rations were changed by giving limestone to lot 1, taking it away from lot 2, giving limestone to lot 3, and substituting buttermilk for mash in lot 4, as shown in Table 2.

Table 1.—Materials Fed, November 1, 1921, to May 30, 1922.

Lot No.	Corn	Mash	Buttermilk	Limestone
1	morning & evening	0	ad libitum	0
2	morning & evening	0	ad libitum	ad libitum
3	morning & evening	ad libitum	0	0
4	morning & evening	ad libitum	0	ad libitum

*Samples ranged from 0.22 to 0.32 per cent CaO

**A previous experiment had shown that the absence of grit during the 8 months laying period of hens confined to the house does not change the production or the composition of the eggs laid.

Table 2.—Materials Fed During June and July, 1922.

Lot No.	Corn	Mash	Buttermilk	Limestone
1	morning & evening	0	ad libitum	ad libitum
2	morning & evening	0	ad libitum	0
3	morning & evening	ad libitum	0	ad libitum
4	morning & evening	0	ad libitum	ad libitum

Analyses of the Feeds. Table 3 contains analyses of the materials fed, made upon average samples. The figures for buttermilk are the averages of three analyses of samples taken at different times, the range of CaO being 0.22 to 0.32 per cent, and of P_2O_5, 0.20 to 0.28 per cent. Analysis of the tankage which composed 20 per cent of the mash gave 51 per cent of protein, 14.7 per cent of calcium oxid and 11.25 per cent of phosphorus pentoxid. An analysis of the buttermilk gave 3 per cent protein.

Table 3.—Analyses of the Materials Fed, Per Cent.

Material	Calcium oxid, CaO	Phosphorus pentoxid, P_2O_5	Excess CaO above that required for $Ca_3P_2O_8$
Corn	0.02	0.65	(Deficit 1.40)
Mash	2.80	2.01	0.44
Buttermilk	0.25	0.24	0
Limestone	49.14	0.01	49.12

The question having arisen after the close of this experiment as to the acidity of the buttermilk, a sample of that then being used at the poultry farm was found to require 133 c.c. of 0.1N alkali per 100 c.c. of buttermilk, using phenolphthalein indicator. The buttermilk was alkaline to methyl orange. No acidity tests were made during the experiments. It should be noted that buttermilk which has been neutralized with lime, soon becomes acid again.

CONSUMPTION OF FEEDS.

An accurate record was kept of the quantities of materials given each lot, each month, and of the quantities remaining uneaten. From this and the mortality record (Table 5) the monthly consumption of these materials, per hen, in each lot, has been computed, as given in Table 4.

Table 4.—Materials Consumed Per Hen, Kilograms.*

Date	Lot 1			Lot 2		
	Corn	Buttermilk	Limestone	Corn	Buttermilk	Limestone
Nov.	2.69	2.54		2.74	2.08	.01
Dec.	2.93	4.71		2.83	2.72	.06
Jan.	2.49	5.30		2.17	4.89	.04
Feb.	1.83	6.89		2.07	5.57	.06
March	1.69	8.24		2.01	7.15	.11
April	1.87	9.67		1.74	7.40	.24
May	2.54	7.85		2.46	6.03	.04
Total	16.04	45.20		16.02	35.84	.56
Ave. for 7 months	2.29	6.46		2.27	5.15	.08
June	2.45	7.70	.10	3.62	11.61	
July	4.28	7.95	.48	3.86	8.44	
Total	6.73	15.65	.58	7.48	20.05	
Ave. for Apr. & May	2.20	8.76		2.10	6.71	.14
Ave. for June & July	3.36	7.82	.29	3.74	10.02	

*The figures were obtained by dividing the total monthly consumption by the number of hens shown in the mortality record (Table 5).

Date	Lot 3			Lot 4			
	Corn	Mash	Limestone	Corn	Mash	Limestone	Buttermilk
Nov.	2.96	.34		2.84	.17	.01	
Dec.	2.30	.59		2.69	.37	.03	
Jan.	2.47	.68		2.22	.41	.05	
Feb.	1.32	.66		1.67	.45	.02	
March	1.82	.97		1.57	.45	.07	
April	1.99	.81		2.40	.52	.09	
May	.75	1.11		1.33	.60	.26	
Total	13.61	5.16		14.72	2.97	.53	
Ave. for 7 months	1.94	.74		2.10	.42	.08	
June	1.90	.72	.04	2.57		.07	10.10
July	1.95	.90	.52	3.05		.36	3.61
Total	3.85	1.62	.56	5.62		.43	13.71
Ave. for Apr. & May	1.37	.96		1.86	.56	.17	
Ave. for June & July	1.92	.81	.28	2.81		.21	6.85

The total consumption of corn per hen during 7 months was the same in lot 1, in the absence of limestone, as in lot 2, with limestone; the consumption of buttermilk during the same time, however, was 26 per cent greater in lot 1 than in lot 2. In both these lots, the consumption of buttermilk increased from month to month until May, when a diminution of about 18 per cent occurred; the consumption of corn, however, diminished somewhat from December to May, when a distinct increase occurred. After limestone had been given to lot 1, a further increase in the consumption of corn per hen was recorded, the average for June and July being 33 per cent greater than that for May; but the average consumption of buttermilk in June and July was the same as that in May and 11 per cent less than the average for April and May. After limestone had been taken from lot 2, the

consumption of both corn and buttermilk per hen increased decidedly, the averages for June and July being 52 per cent and 40 per cent greater, respectively, than those for May.

The total consumption of corn per hen in lots 3 and 4, during 7 months, was less than in lots 1 and 2, and less in lot 3, in the absence of limestone, than in lot 4. The consumption of mash per hen in lot 3, in the same time, was 74 per cent greater than in lot 4. The monthly consumption of corn showed a general decrease in both lots, and that of mash a general increase, during the 7 months. Substituting buttermilk for mash in lot 4 was followed by a distinct increase in consumption of corn, the average per hen in June and July being 34 per cent greater than in May and June. Adding limestone to the diet of lot 3 was followed by a marked increase in the consumption of grain and a decrease in the consumption of mash.

The average consumption of limestone per hen for the first 7 months was the same in lot 4 as in lot 2, but the substitution of buttermilk for mash in the diet of lot 4 was followed in the second month by a distinct increase in the consumption of limestone. The average consumption of limestone in lot 1, in June and July, was twice as great as the average for lot 2 during the first 7 months, or in April and May.

EGG PRODUCTION AND MORTALITY.

Trap-nest records were kept, eggs laid on the floor being counted in the total. If a hen died she was credited in proportion to the time she had remained in the experiment. On June 1, three hens from lot 1 and four from each of the other lots were killed, for analysis, and the experiment was continued with the remaining hens, under the change of diet already indicated.

The table gives the average egg production, by months, and the number of hens in the experiment each month, for each lot.

Table 5.—Monthly Mortality and Egg Record.

MONTH	Lot 1 Corn, buttermilk			Lot 2 Corn, buttermilk, limestone		
	Number of hens.*	Total No. of eggs per month.	No. of eggs per hen per month.	Number of hens.	Total No. of eggs per month.	No. of eggs per hen per month.
Nov.	10.	3.	.3	10.	0.	0.
Dec.	10.	48.	4.8	10.	64.	6.4
Jan	10.	46.	4.6	10.	149.	14.9
Feb.	10.	62.	6.2	10.	89.	8.9
March	10.	85.	8.5	9.9(2)	184.	18.6
April	9.6(3)	99.	10.3	9.	165.	18.3
May	7.8(3)	74.	9.5	9.	178.	19.8
Sum, 7 months		417.	44.2		829.	86.9
		Limestone added			Limestone removed	
June	4.	65.	16.0	5.	100.	20.0
July	4.	68.	17.0	5.	42.	8.6
Sum, 2 months		133.	33.		142.	28.6

Table 5.—Continued.

MONTH	Lot 3 Corn, mash			Lot 4 Corn, mash, limestone		
	Number of hens.*	Total No. of eggs per month.	No. of eggs per hen per month.	Number of hens.	Total No. of eggs per month.	No. of eggs per hen per month.
Nov.	10.	0.	0.	10.	3.	3.
Dec.	10.	16.	1.6	10.	26.	2.6
Jan.	9.3(1)	55.	5.9	10.	53.	5.3
Feb.	9.	65.	7.2	10.	82.	8.2
March	9.	78.	8.7	10.	96.	9.6
April	9.	65.	7.2	9.7	88.	9.1
May	9.	68.	7.6	9.	79.	8.8
Sum, 7 months		347.	38.2		427.	43.9
		Limestone added		Buttermilk instead of mash		
June	5.	21.	4.2	4.4	69.	15.7
July	4.	10.	2.5	3.7	33.	8.9
Sum, 2 months		31.	6.7		102.	24.6

*If a hen died during the month, she was counted as N/30 of a hen in determining the average egg production per hen for that month, "N" being the number of days she lived in the month.

(1) Cause of death unknown.
(2) Death caused by canker on face.
(3) Broken egg in oviduct. Shell thin and incompletely deposited.

The average number of eggs per hen, for 7 months, in lot 1, without limestone, is only about half that for lot 2, an increase of 42.7 eggs per hen, or 96.6 per cent, having been caused by the addition of limestone to the corn-buttermilk ration. In lots 3 and 4, the averages per hen for 7 months show a gain of only 5.7 eggs per hen, or 14.9 per cent, from the addition of limestone to the grain-mash diet. Thus, under the conditions of this experiment, limestone is much more effective, for egg production, in connection with buttermilk than in connection with tankage. The average egg production, per hen, for 7 months, is practically the same in lot 1 as in lot 4. It seems from this that the lack

of calcium carbonate limits the egg producing value of the efficient proteins in the buttermilk supplied to lot 1, tho some constituent (lactic acid, vitamins) of the buttermilk, other than protein, may have affected the result. On the other hand, if the difference in egg production between lots 2 and 4 depends upon protein, the quantity of animal protein consumed may not have been sufficient for maximum egg production in lot 4, even in the presence of sufficient calcium carbonate. Estimating that buttermilk contains 3 per cent of protein, tankage 51 per cent and whole eggs 12 per cent, lot 4 consumed only 303 grams of animal protein and put out 270 grams as eggs, whereas lot 2 consumed 1075 grams of animal protein and put out 558 grams as eggs. The cause of the remarkable difference observed here is to be investigated further.

The eggs produced in April were photographed and are shown in Fig. 1.

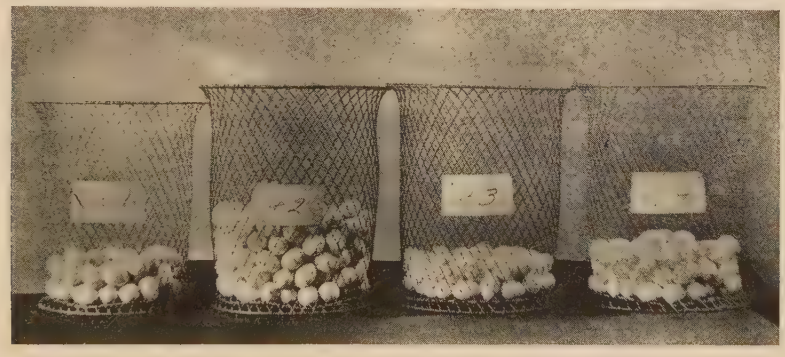

Fig. 1. Eggs laid in April; left to right, lots 1, 2, 3 and 4.

Under the conditions of this experiment, the tankage-mash did not permit as long an egg laying period in lot 3 as the buttermilk did in lot 1, as shown by the more rapid decrease in egg production in lot 3 than in lot 1. This is also shown by the increased egg production after the substitution of buttermilk for the mash in lot 4.

Only two shell-less eggs were produced during the experiment. These were in lot 1, in December, 1921, among the

first eggs laid; but inasmuch as no more were produced, they seem not to have any connection with deficiency of calcium.

Mortality. The mortality records of lots 2, 3 and 4 are practically the same and are normal; lot 1 shows a somewhat greater mortality. Two of the three hens of lot 1 that died each had a broken egg in the oviduct, the shells being thin and only partly deposited, a condition which seems to have resulted from the lack of available calcium carbonate for the formation of shell, there being an abundant supply of material to form the edible portion of the egg. The death of the third hen was caused by the depositing of a yolk in the abdominal cavity. One of the hens in lot 1 had broken down so that she could not stand, and was killed, for analysis, May 24. None of the hens in this lot were as sprightly and active, after the experiment was well advanced, as were those that received limestone.

Effect of Changing the Rations. Table 6 gives the average egg production per hen for the 2-month period before and after the change of ration, including all hens except one in lot 3, which has no eggs to her credit in that time.

Table 6.—Average Egg Produciton Per Hen for 2-Month Periods.

	Lot 1	Lot 2	Lot 3	Lot 4
After changing ration—June and July	33.3	28.4	6.9	20.5
Before changing ration—April & May	19.9	38.0	14.8	17.9
Difference	+13.4	—9.6	—7.9	+2.6
Percentage of increase (+) or decrease (—)	+67	—25	—53	+15

The results are striking, but the comparison is hardly fair because of the considerable number of hens taken out of the experiment May 30. A comparison of the records of only those hens that remained in the experiment to the end, would be better, in studying the effect of the change of diet. The considerable number of eggs laid on the floor in lot 2, however, an uncertain number of which were laid by the hens in question, brings a difficulty into the computation. Assuming that the floor eggs were equally distributed among the hens, which seems preferable to disregarding the floor eggs, the egg production of the

hens under consideration, from April to July, inclusive, may be summarized as follows:

Four hens, fed corn and buttermilk, *without limestone,* laid 85 eggs in April and May. The same hens, on the same feed, *with limestone,* laid 133 eggs in June and July, an increase of 48 eggs, or 56 per cent.

Four hens, fed corn and buttermilk, *with limestone,* laid 141 eggs in April and May. The same hens, on the same feed, *without limestone,* laid 113 eggs in June and July, a decrease of 28 eggs, or 20 per cent.*

Three hens, fed corn and mash, *without limestone,* laid 46 eggs in April and May. The same hens, on the same feed, *with limestone,* laid 26 eggs in June and July, a decrease of 20 eggs, or 43 per cent.

Three hens, fed corn and mash, *with limestone,* laid 43 eggs in April and May. The same hens, fed corn, *with buttermilk instead of mash,* also with limestone, laid 77 eggs in June and July, an increase of 33 eggs, or 77 per cent.

The importance of calcium carbonate in connection with the corn-buttermilk diet is apparent; calcium carbonate had little effect, however, in connection with corn and mash. Apparently, an increased consumption of mash was needed to bring about satisfactory egg production with the latter diet. The substitution of buttermilk for mash, in lot 4, increased production materially. The great efficiency of buttermilk, both with and without calcium carbonate, is apparent. It should be mentioned here, however, that in a previous experiment** hens on a diet of corn and oats, with a dry mash of wheat bran, midlings, ground oats, tankage and charcoal, produced in 8 months from 42 to 79 per cent more eggs per hen when they received limestone than when they did not. In a still earlier experiment,*** using a similar mash, the hens receiving limestone produced in 5 months 86 per cent more eggs per hen than those that were not given a calcareous supplement.

*Prorating the floor eggs among those hens only whose egg production varied abnormally, suggesting that they were laying floor eggs, gives 152 eggs in April and May, and 107 in June and July, a decrease of 45 eggs, or 29 per cent, instead of 20 per cent.

**Kentucky Agricultural Experiment Station, Bulletin 250, p. 337.

***Kentucky Extension Circular No. 66.

WEIGHT OF THE EGGS, SHELLS AND CONTENTS.

The eggs laid by each lot, in each monthly period of 30 days, were washed, dried, weighed, and the contents carefully separated from the shells. The shells from each lot, including the membranes and some adhering white, were weighed together, both fresh and after drying in an oven for 24 hours at 120°C. The average weights per egg, calculated from these weighings, and the monthly average percentages of dry shell, in the whole egg, are given in Table 7.

Table 7.—Monthly Average Weights of the Egg. Dry Shell, and Contents, in Grams, and Percentage of Shell.

	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July
	Lot 1—Corn, buttermilk							Limestone added	
Whole egg	45.4	48.4	48.6	50.3	49.8	49.2	47.1	52.2	55.6
Dry shell	4.3	3.6	3.8	3.6	3.8	3.5	3.2	4.6	4.5
Contents	41.1	44.8	44.8	46.7	46.0	45.7	43.9	47.6	51.1
Percentage of shell	9.7	7.4	7.8	7.1	7.6	7.1	6.8	9.0	8.1
	Lot 2—Corn, buttermilk, limestone							Limestone withdrawn	
Whole egg	.....	49.3	52.9	52.5	56.3	52.4	54.3	50.3	49.1
Dry shell	.....	4.8	4.9	4.5	5.2	4.6	5.1	4.0	3.6
Contents	.....	44.5	48.0	48.0	51.1	47.8	49.2	46.3	45.5
Percentage of shell	.....	9.7	9.3	8.6	9.2	9.0	9.4	8.0	7.3
	Lot 3—Corn, mash							Limestone added	
Whole egg	.....	47.1	48.5	50.5	51.8	48.3	48.1	48.5	48.3
Dry shell	.....	4.2	4.4	4.4	4.5	4.1	4.1	4.4	4.4
Contents	.....	42.9	44.1	46.1	47.3	44.2	44.0	44.1	43.9
Percentage of shell	.....	8.9	9.1	8.7	8.6	8.5	8.5	9.1	9.0

	Lot 4—Corn, mash, limestone						Buttermilk vice mash		
Whole egg	45.0	49.3	50.2	52.5	53.1	51.5	49.3	52.0	50.3
Dry shell	4.8	5.2	5.0	5.5	5.2	4.7	4.6	4.7	5.1
Contents	40.2	44.1	46.2	47.0	47.9	46.8	44.7	47.3	45.2
Percentage of shell	10.7	10.5	10.5	10.5	9.8	9.1	9.3	9.0	10.1

The general averages for the two periods, before and after the change of diet, seven months and two months, respectively, have been brought together in Table 8, for convenient comparison.

Table 8.—Average Weights of the Whole Egg, Dry Shell and Contents, and Percentage of Shell.

Period	Lot and Ration	Whole egg	Shell	Contents	Percentage of Shell
Nov. 1 to May 30	1—Corn, buttermilk	48.9	3.6	45.3	7.4
	2—Corn, buttermilk, limestone	53.5	5.0	48.5	9.3
	3—Corn, mash	49.4	4.3	45.1	8.7
	4—Corn, mash, limestone	51.3	5.0	46.3	9.7
June and July	1—Corn, buttermilk, limestone	53.9	4.6	49.3	8.5
	2—Corn, buttermilk	49.9	3.9	46.0	7.8
	3—Corn, mash, limestone	48.4	4.4	44.0	9.1
	4—Corn, buttermilk, limestone	51.5	4.8	46.7	9.3

Tables 7 and 8 show the eggs from the hens receiving limestone, lots 2 and 4, are distinctly heavier than those from the hens that did not get limestone. They were larger, also, the difference in size being easily apparent to the eye. (Fig. 1.) The average weight of an egg for lot 2 for the first 7 months is 4.6 grams, or 9.4 per cent greater than the average for lot 1, and the average for lot 4 exceeds that of lot 3 by 1.9 grams, or 3.8 per cent.

Addition of limestone to the corn-buttermilk and the corn-tankage rations increased the average monthly weight of an egg laid, after the first month. This is true not only because a heavier eggshell was formed, but also because the edible portion was heavier after the second month and so continued for 5 months until the ration was changed, after which time lot 1, which had limestone added to its ration, produced a heavier shell and contents than lot 2, which had been deprived of limestone in their ration at that time. The average weight of the eggs is slightly greater in lot 3 than in lot 1, presumably because fewer eggs were produced and more calcium was consumed in the same time.

The average weight of shell is lighter after the first month in lot 1 than in the other lots and the average weights in lots 2 and 4 are equal, and greater than that in lot 3. These relations hold true until June 1, when the rations were changed; after this the average weight of the dry shells in lot 1 becomes heavier than that in lot 2, but the average weight of the shells in lot 4 is somewhat greater than that of lot 3. The shells of the eggs laid by the hens receiving no limestone are thinner and lighter than those of the eggs laid by the hens receiving it. The addition of limestone to the ration of lot 3 increased the weight of the shells slightly.

The average weight of the contents of the eggs produced in the first 7 months is greatest in lot 2, being 2.2 grams, or 4.7 per cent, heavier than lot 4 and 3.3 grams, or 7.5 per cent, heavier than that in lots 1 and 3, which are practically equal in weight. The average for June and July, however, is greatest in lot 1, following the addition of limestone to the corn-buttermilk diet. The monthly average shows a gradual increase in weight of contents during the first three or four months, after which it diminishes gradually until the change of diet, when the weight of contents increases again in lots 1, 3 and 4. The increase in lot 1 is very striking, the weight in July being 7.2 grams greater than in May, an increase of 16 per cent.

The averages for June and July show that adding limestone to the ration of lot 1 increased the weight of the shell 1 gram,

or 28 per cent, and that of the contents 4 grams, or 8.7 per cent, above the average for the first 7 months. Taking limestone away from lot 2 decreased the weight of the shell 1.1 grams, or 22 per cent, and that of the liquid contents 2.5 grams, or 5.1 per cent, as compared with the average for the first 7 months.

Giving limestone to lot 3 was followed by an insignificant gain in the weight of the egg shell and a decrease of 1.1 grams, or 2.4 per cent, in the weight of the contents.

CALCIUM AND PHOSPHORUS CONTENT OF THE EGGS.

After separating the shells, the contents of all eggs laid each month by each lot were thoroly mixed and a portion of this composite was ashed, after the addition of sodium carbonate, as described in Bulletin 250, page 339. The dried shells were ground to pass a 0.5 mm. mesh sieve and a weighed portion burned to constant weight, for analysis. Calcium and phosphorus were determined in the ash of contents and of shells, the former by the method of McCrudden;* the latter by the volumetric method of the Association of Official Agricultural Chemists.** Table 9 gives the average percentages of CaO and P_2O_5 found, and Table 10, the average weights in grams per egg, computed from these percentages and the data in Table 8.

*McCrudden, F. H., J. Biol. Chem., 1909-10, Vol. VII, p. 83.
**Official and Tentative Methods of Analysis of the A. O. A. C., Washington, D. C., September, 1920, page 3.

Table 9.—Average Percentage of CaO and P_2O_5 in the Whole Egg, the Shell, and the Contents.

Period	Lot and Ration	Whole Egg		Dry Shell		Contents	
		CaO	P_2O_5	CaO	P_2O_5	CaO	P_2O_5
Nov. 1 to May 30	1—Corn, buttermilk	3.78	.44	50.6	.36	.071	.45
	2—Corn, buttermilk, limestone	4.79	.42	50.6	.34	.068	.43
	3—Corn, mash	4.58	.47	51.9	.37	.071	.48
	4—Corn, mash, limestone	5.11	.45	51.8	.34	.067	.46
June and July	1—Corn, buttermilk, limestone	4.34	.45	50.2	.35	.065	.46
	2—Corn, buttermilk	3.89	.43	49.0	.36	.070	.43
	3—Corn, mash, limestone	4.71	.46	51.1	.34	.070	.47
	4—Corn, buttermilk, limestone	4.89	49	51.9	.37	.071	.50

The percentage of P_2O_5 is practically uniform in the several lots. The percentage of CaO in the whole egg is greatest in lot 4 and least in lot 1. This is determined mainly by the proportion of shell. The shells of lots 3 and 4, however, have a somewhat higher percentage of CaO than those of lots 1 and 2.

Table 10.—Average Weights in Grams Per Egg of CaO and P_2O_5 in the Whole Egg, Dry Shell, and Contents.

Period	Lot and Ration	Whole Egg		Dry Shell		Contents	
		CaO	P_2O_5	CaO	P_2O_5	CaO	P_2O_5
Nov. 1 to May 30	1—Corn, buttermilk	1.85	.215	1.82	.013	.032	.202
	2—Corn, buttermilk, limestone	2.56	.226	2.53	.017	.033	.209
	3—Corn, mash	2.23	.231	2.23	.016	.032	.215
	4—Corn, mash, limestone	2.62	.229	2.59	.017	.031	.212
June and July	1—Corn, buttermilk, limestone	2.34	.245	2.31	.016	.032	.229
	2—Corn, buttermilk	1.94	.213	1.91	.014	.032	.199
	3—Corn, mash, limestone	2.28	.222	2.25	.015	.031	.207
	4—Corn, buttermilk, limestone	2.52	.252	2.49	.018	.033	.234

In the eggs of lots 2 and 4, where sufficient calcium was available, the weight of CaO per whole egg is practically the same, and greater than in those of lots 1 and 3, where the supply of calcium was limited. The eggs of lot 3 contain considerably more calcium per whole egg than those of lot 1, the latter containing least of all. The average weights of CaO in the whole eggs vary with the weights of the eggs, in all lots. The average weights of P_2O_5 per egg are practically the same in the four lots. The addition of limestone to the rations under consideration did not alter the P_2O_5 content of the egg shells materially nor did the change of protein affect it.

The weights and percentages of CaO and P_2O_5 are remarkably constant in the contents of the eggs from the several lots, during the whole experiment, confirming the observation reported in Bulletin 250.

CALCIUM AND PHOSPHORUS REQUIRED FOR EGG PRODUCTION

Table 11 shows the average quantities of CaO and P_2O_5 per hen, contained in the eggs produced by each lot, compared with the quantities in the food and limestone consumed. In lots 1, 2 and 3 the percentage of the CaO in the food utilized in the production of eggs is nearly the same tho the weights are very different for the three lots. Lot 4 used a much smaller proportion of its calcium intake than the other lots. Lots 1 and 3 utilized the same percentage of the P_2O_5 ingested, while lots 2 and 4 utilized a larger proportion than lots 1 and 3, the percentage of utilization being the highest in lot 2. Lots 2 and 4 put into their eggs considerably more calcium than was contained in the feed eaten, the limestone supplement supplying the excess. In lot 2, this excess is 140 per cent of the weight contained in the feed, and in lot 4 it is 34 per cent. Lots 1 and 3, which did not have limestone, put into their eggs 71 per cent and 59 per cent, respectively, of the amounts contained in their feed. Lack of sufficient calcium in the form of carbonate seems to have been a limiting factor in these two lots.

Table 11.—Intake of CaO and P_2O_5 and Outgo in Eggs, in 7 Months, as Grams Per Hen and Percentage Utilized in the Eggs.

	Lot 1 Corn, Buttermilk	Lot 2 Corn, Buttermilk, Limestone	Lot 3 Corn, Mash	Lot 4 Corn, Mash Limestone
CaO in the feed eaten	116.	93.	147.	86.
CaO in the limestone	0	275.	0	260.
Total intake of CaO	116.	368.	147.	346.
CaO in the eggs	82.	223.	86.	115.
Percentage of intake used in eggs	71.	66.	59.	33.
CaO in eggs exceeds that in feed		130.		29.
P_2O_5 in the feed eaten	213.	190.	192.	155.
P_2O_5 in the limestone	0	trace	0	trace
P_2O_5 in the eggs	10.	19.	9.	10.
Percentage of intake used in eggs	4.7	10.0	4.7	6.4
P_2O_5 in feed exceeds that in eggs	203.	171.	183.	145.

WEIGHTS AND THRIFTINESS OF THE HENS.

Each hen was weighed at the beginning of each monthly period. The average weights are given in Table 12. Notes of the condition of the hens were made at regular intervals and when a hen died a post mortem was performed to determine the cause of her death.

Table 12.—Average Monthly Weight of the Hens in Each Lot.

	Lot 1 Corn, Butter-milk	Lot 2 Corn, Butter-milk, Lime-stone	Lot 3 Corn, Mash	Lot 4 Corn, Mash, Lime-stone
November 1, 1921	1096	1121	1079	1071
December 1, 1921	1294	1347	1182	1185
December 31, 1921	1407	1603	1359	1301
January 30, 1922	1460	1526	1454	1387
March 1, 1922	1491	1569	1415	1345
March 31, 1922	1366	1565	1409	1324
April 30, 1922	1335	1444	1334	1265
May 30, 1922	1333	1479	1321	1186

The figures in Table 12 show that the average weight of a hen was nearly the same in each lot at the beginning of the experiment. The hens receiving buttermilk, especially the ones receiving buttermilk and limestone, made a more rapid growth than those receiving tankage. Lot 4 made a lower average weight curve than lot 3, which did not receive limestone in addition to the corn and tankage.

Condition of the Birds. It was noted on January 30, 1922, that the hens in lot 1 did not seem as bright and active as those in lot 2 and during the 4 months following they seemed drowsy and were lacking in normal activity (groggy). By May 30 the general activity of the hens in lot 1 was much lowered. By May 24, one of them, hen 396, was unable to stand and was very nervous and tremulous. This condition is shown in the photograph in which this hen is compared with an average hen

in lot 2. Hen No. 396 was killed May 24, for analysis. The addition of limestone to their diet, on May 30, brought about normal activity and condition of the four hens remaining in this lot.

Fig. 2. Hen 396 (right) and a normal hen (Lot 2.)

On March 15, 1922, it was noticed for the first time that the birds in lot 1 had started eating eggs; this condition continued until limestone was added to the ration, May 30, when egg eating stopped abruptly.

During the experiment the hens in lot 2 were normal, no egg eating occurred and they were noticeably more active and in a better condition than those in lots 3 and 4 at all times. No difference was observed in the activity and general condition of the hens in lots 3 and 4 thruout the experiment. Presumably the calcium content of the tankage sufficed to keep these hens in condition without the limestone.

CALCIUM AND PHOSPHORUS CONTENT OF CARCASS AND LEG-BONES.

On November 1, 1921, at the beginning of the experiment, 2 hens (1st controls) that were of the same age, breeding and raising as all other hens in the experiment, were killed and the

heads, feathers, skin, feet and entire intestinal tract were removed and discarded. The four large leg bones (femur and tibia) were dissected out and, after being freed from adhering material, were weighed, dried, weighed again and burned, separately from the remaining part of the carcass, and the ash analyzed. The carcass was treated in the same way except that the dry weight was not determined. The CO_2-free ash, CaO and P_2O_5 were determined in the ash, by the same methods as were used in analyzing the egg shells. Hens that died during the experiment were analyzed also, except that when death was caused by a condition which did not result from faulty nourishment the hen was weighed but not analyzed.

On May 30, 1922, when the ration was changed, 3 hens from lot 1, and 4 hens from each other lot were selected at random, and also hens (2nd controls) that were the same in age and breeding as all other hens in the experiment but had been allowed the freedom of the meadow range since hatching, were killed and similarly dissected and analyzed. The analysis of hen 396, which was broken down, in lot 1, and was killed May 24, is used in the average for this lot, in Tables 13 and 14. The average analyses of the carcasses, that is, the flesh and bones, except the leg bones, head, feet, skin, feathers and digestive tract, are given in Table 13; the analyses of the leg bones are given in Table 14.

Table 13.—Average Analyses of the Carcasses* of Hens from all Lots.

	1st Control 11-1-'21	2nd Control 6-1-'22	Lot 1 Corn, buttermilk. 6-1-'22	Lot 2 Corn, buttermilk, limestone 6-1-'22	Lot 3 Corn mash. 6-1-'22	Lot 4 Corn, mash, limestone 6-1-'22
Number of hens in the average....	2	2	4	4	4	4
Average weight of hens, grams....	1209	1040	1186	1413	1232	1138
Av. wt. of fresh carcass, without leg-bones, grams	689	623	746	893	782	695
Av. wt. of CO_2-free ash of carcass	22.80	22.34	18.82	29.66	25.35	22.88
Perctg. of CO_2-free ash in carcass	3.31	3.59	2.56	3.29	3.24	3.30
Av. wt. of CaO in carcass, grams	9.58	10.07	8.10	13.02	11.28	10.23
Percentage of CaO in carcass.....	1.39	1.62	1.09	1.46	1.44	1.47
Perctg. of CaO in the CO_2-free ash	42.03	45.09	42.75	44.00	44.39	44.70
Av. wt. of P_2O_5 in carcass, grams	10.09	9.79	8.43	13.19	11.22	10.34
Percentage of P_2O_5 in carcass.....	1.46	1.55	1.13	1.48	1.44	1.49
Perctg. of P_2O_5 in the CO_2-free ash	44.21	43.84	44.83	45.02	44.35	45.16
CaO required to form $Ca_3P_2O_8$ with the P_2O_5 exceeds CaO found, grams per carcass.....	2.37	1.52	1.88	2.60	2.00	2.01

*Meaning everything except the head, skin, feathers, digestive tract, leg-bones and feet.

The average weight of the first controls is greater than that of the second controls, tho they were 7 months younger; this may be because the second controls were killed at the end of their laying season, a time when all hens have lost weight. The weight of the CO_2-free ash, also, is less in the second controls. The average weight of CaO in the carcass of the second controls is greater than that of the first controls, whereas the average weight of P_2O_5 is slightly less in the second controls than in the first.

The average weight of the 4 hens in lot 1 is considerably less than that of the hens in lot 2, but the average weight of the hens in lot 4 is less than that of those in lot 3. The percentages of CO_2-free ash in the carcass of the first controls and lots 2, 3, and

4 are practically the same, while that of lot 1 is much smaller and that of the second control, killed May 30, is somewhat larger than the others.

Table 14.—Average Analyses of Leg-Bones of Hens from all Lots.

	1st Control 11-1-'21	2nd Control 6-1-'22	Lot 1 Corn, buttermilk, 6-1-'22	Lot 2 Corn, buttermilk, limestone 6-1-'22	Lot 3 Corn mash, 6-1-'22	Lot 4 Corn, mash, limestone 6-1-'22
Number of hens in the average	2	2	4	4	4	4
Av. wt. of 4 leg-bones, grams	26.49	27.60	27.84	31.72	27.77	30.34
Same, dried at 100° C. for 24 hrs. grams	17.16	17.06	13.01	20.37	16.28	20.27
Percentage of dry matter	64.8	61.8	46.7	64.2	58.6	66.8
Av. wt. of CO_2-free ash from 4 leg-bones, grams	7.00	8.39	6.10	10.61	8.69	10.13
Percentage of same in the fresh leg-bones	26.4	30.4	21.9	33.5	31.3	33.4
Percentage of same in the dried leg-bones	40.8	49.0	46.8	51.5	53.6	48.9
Av. wt. of CaO in 4 leg-bones, gms.	3.85	4.59	3.33	5.81	4.75	6.55
Percentage of CaO in the fresh leg-bones	14.5	16.6	11.9	18.3	17.1	21.6
Perctg. of CaO in the dry leg-bones	22.4	26.9	25.6	28.5	29.2	32.3
Perctg. of CaO in the CO_2-free ash	54.95	54.62	54.51	54.82	54.67	55.06
Av. wt. of P_2O_5 in 4 leg-bones	2.96	3.51	2.54	4.37	3.60	4.91
Perctg. of P_2O_5 in fresh leg-bones	11.2	12.7	9.1	13.8	12.9	16.2
Perctg. of P_2O_5 in dry leg-bones	17.2	20.6	19.5	21.5	22.1	24.2
Perctg. of P_2O_5 in the CO_2-free ash	42.18	41.81	41.70	41.24	41.47	41.24
CaO exceeds that required to form $Ca_3P_2O_8$ with the P_2O_5, grams in 4 bones	0.35	0.44	0.32	0.64	0.49	0.74

The average weights of the fresh bones and of the CO_2-free ash, CaO and P_2O_5 in the bones, both fresh and dry, are larger in the second controls than in the first controls. The weights of the dried bones, however, and the percentages of CaO and P_2O_5 in the CO_2-free ash of both controls are nearly the same.

The average weight of the leg bones in lot 1 is less than that of lot 2 and the leg bones of lot 3 are lighter than those of lot 4. In both cases the lots receiving limestone in their ration produced heavier bone. This fact is further shown in the quantities of dried bone, CO_2-free ash and the CaO and P_2O_5 content. The average analyses of the leg bones of the hens in lots 2 and 4 are very similar, while those of lots 1 and 3 show a greater variation. Lot 3 has a higher calcium and phosphorus content than lot 1, presumably because of the supply of calcium and phosphorus in the mash received by lot 3.

In the case of lot 1, the CaO and P_2O_5 content of the leg bones is smaller than that of the first control, which indicates that the insufficiency of calcium in the food causes a marked withdrawal of these elements from the bones of the hens.

Notwithstanding the differences in the percentages of CO_2-free ash, the percentages of CaO and P_2O_5 in the CO_2-free ash are fairly constant. The ratio of calcium to phosphorus, however, shows a slightly higher proportion of calcium in the bones of the hens that received limestone, suggesting the presence in these of more calcium carbonate than in the others.

From the foregoing figures and discussion, the conclusions in the summary at the beginning of this bulletin seem to be justified.

TABULATED DATA.

In the body of this bulletin mainly averages have been used. The following tables are added for the purpose of presenting for reference the original findings in greater detail. The analyses of hens Nos. 397 and 393, which are not included in the averages, are included in Tables 17 and 18 to complete the record.

Table 15.—Individual Egg and Mortality Record.

Lot 1.—Corn, buttermilk, without limestone								With limestone	
Hen No.	Nov. 1921	Dec. 1921	Jan. 1922	Feb. 1922	Mch. 1922	Apr. 1922	May 1922	June 1922	July 1922
388	0	0	8	9	10	11	13	11	18
389	0	8	9	7	12	10	8	Killed June 1	
390	0	5	2	9	13	11	11	Killed June 1	
392	0	8	0	7	13	12	13	17	16
393	0	0	3	2	4	10	Dead May 1		
395	2	6	5	7	6	6	3	14	12
396	0	0	6	3	4	4	4	Killed May 24	
397	0	2	4	3	6	5	Dead Apr. 17		
398	1	9	5	8	7	11	8	Killed June 1	
399	0	5	3	5	10	12	11	22	21
Floor	0	5*	1	2	0	5	3	1	1
Total	3	48	46	62	85	99	74	65	68

*Two of these shell-less.

Lot 2.—Corn, buttermilk, limestone								Without limestone	
376	0	0	9	8	17	21	18	Killed Jun. 1	
377	0	12	19	17	22	18	22	21	6
									D. July 28
378	0	0	15	10	21	19	18	Killed Jun. 1	
379	0	0	4	4	5	10	13	Killed Jun. 1	
380	0	8	17	5	12	13	12	Killed Jun. 1	
381	0	11	15	16	24	23	24	28	10
383	0	4	1	2	4	2	3	12	8
384	0	5	15	7	21	17	15	11	2
385	0	2	10	11	23	12	15	17	14
387	0	5	11	0	8	D. Mar. 27			
Floor	0	17	42	9	27	30	38	11	2
Total	0	64	149	87	184	165	178	100	42

Lot 3.—Corn, mash, without limestone								With limestone	
Hen No.	Nov. 1921	Dec. 1921	Jan. 1922	Feb. 1922	Mch. 1922	Apr. 1922	May 1922	June 1922	July 1922
228	0	0	D. Jan. 8						
229	0	2	10	7	5	2	8	Killed Jun. 1	
239	0	0	0	4	7	6	4	Killed Jun. 1	
250	0	4	9	12	13	13	9	Killed Jun. 1	
251	0	4	10	13	10	9	10	3	4
252	0	0	6	11	13	13	9	Killed Jun. 1	
253	0	5	8	5	7	2	4	4	1
258	0	0	0	0	1	0	0	0	0
259	0	0	3	2	5	7	9	6	2
260	0	1	6	6	10	9	6	4	D. Jun. 28
Floor	0	0	3	5	7	4	9	4	3
Total	0	16	55	65	78	65	68	21	10

Lot 4.—Corn, mash, with limestone								Buttermilk, vice mash	
262	0	8	8	14	10	10	7	8	10
263	3	8	5	5	13	8	11	Killed Jun. 1	
264	0	0	8	14	13	12	6	Killed Jun. 1	
266	0	0	12	9	9	7	8	15	6
									D. July 21
268	0	0	0	7	10	7	8	15	8
272	0	0	0	2	9	9	8	Dead June 13	
273	0	0	3	8	9	14	12	Killed Jun. 1	
276	0	2	2	6	8	2	1	2	4
279	0	3	6	8	4	6	7	Killed Jun. 1	
288	0	0	3	2	4	1	D. Apr. 22		
Floor	0	5	6	7	7	12	11	29	5
Total	3	26	53	82	96	88	79	69	33

Table 16.—Average Monthly Weight of an Egg, Dry Shell and Liquid Part and the Quantities of CaO and P_2O_5 Therein, Expressed in Grams and Percentages.

	Month	Monthly av. wt. 1 egg.	Monthly av. wt. liquid part of 1 egg.	Monthly av. wt. CaO in liquid part of 1 egg.	Monthly av. per cent CaO in liquid part.	Monthly av. wt. P_2O_5 in liquid part of 1 egg.	Monthly av. per cent P_2O_5 in liquid part.	Monthly av. wt. of 1 dry shell.	Monthly av. wt. CaO in 1 dry shell.	Monthly av. per cent CaO in dry shell.	Monthly av. wt. P_2O_5 in 1 shell.	Monthly av. per cent of P_2O_5 in dry shell.
		Gms.	Gms.	Gms.	Per Ct.	Gms.	Per Ct.	Gms.	Gms.	Per Ct.	Gms.	Per Ct.
Lot 1 Corn, buttermilk With limestone	Nov.	45.4	41.1	.029	.071	.185	.45	4.3	2.22	51.6	.017	3.95
without limestone.	Dec.	48.4	44.8	.032	.071	.206	.46	3.6	1.67	46.4	.013	3.61
	Jan.	48.6	44.8	.030	.067	.202	.45	3.8	1.96	51.6	.013	3.42
	Feb.	50.3	46.7	.032	.069	.205	.44	3.6	1.85	51.4	.012	3.33
	Mar.	49.8	46.0	.032	.070	.203	.44	3.8	1.95	51.3	.014	3.68
	Apr.	49.2	45.7	.033	.072	.206	.45	3.5	1.79	51.1	.012	3.43
	May	47.1	43.9	.030	.068	.193	.44	3.2	1.66	51.9	.012	3.75
	June	52.2	47.6	.032	.067	.228	.48	4.6	2.35	51.1	.016	3.48
	July	55.6	51.1	.031	.061	.230	.45	4.5	2.27	50.4	.016	3.55
Lot 2, Corn, buttermilk, Without limestone	Nov.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	Dec.	49.3	44.5	.029	.065	.197	.44	4.8	2.47	51.5	.017	3.54
with limestone.	Jan.	52.9	48.0	.031	.065	.216	.45	4.9	2.57	52.5	.019	3.88
	Feb.	52.5	48.0	.032	.067	.226	.47	4.5	2.32	51.6	.016	3.56
	Mar.	56.3	51.1	.036	.070	.211	.41	5.2	2.69	51.7	.018	3.46
	Apr.	52.4	47.8	.033	.069	.202	.42	4.6	2.38	51.7	.016	3.48
	May	54.3	49.3	.033	.067	.203	.41	5.0	2.59	51.8	.018	3.60
	June	50.3	46.3	.033	.071	.204	.44	4.0	2.04	51.0	.014	3.50
	July	49.0	45.4	.031	.068	.194	.43	3.6	1.77	49.2	.014	3.89

Month		Monthly av. wt. 1 egg.	Monthly av. wt. liquid part of 1 egg.	Monthly av. wt. CaO in liquid part of 1 egg	Monthly av. per cent CaO in liquid part.	Monthly av. wt. P_2O_5 in liquid part of 1 egg	Monthly av. per cent P_2O_5 in liquid part.	Monthly av. wt. of 1 dry shell.	Monthly av. wt. CaO in 1 dry shell.	Monthly av. per cent CaO in dry shell.	Monthly av. wt. P_2O_5 in 1 shell.	Monthly av. per cent of P_2O_5 in dry shell.
		Gms.	Gms.	Gms.	Per Ct.	Gms.	Per Ct.	Gms.	Gms.	Per Ct.	Gms.	Per Ct.
Lot 3, Corn, mash, With limestone.	Nov.	47.1	42.9	.030	.070	.190	.44	4.2	2.15	51.2	.016	3.81
	Dec.	48.5	44.1	.032	.073	.203	.46	4.4	2.30	52.3	.016	3.64
	Jan.	50.5	46.1	.032	.069	.226	.49	4.4	2.33	53.0	.016	3.64
	Feb.	51.8	47.3	.035	.074	.232	.49	4.5	2.31	51.3	.016	3.56
	Mar.	48.3	44.2	.030	.068	.204	.46	4.1	2.12	51.7	.015	3.66
	Apr.	48.1	44.0	.030	.068	.209	.47	4.1	2.10	51.2	.015	3.66
	May											
Without limestone.	June	48.5	44.1	.031	.070	.194	.44	4.4	2.30	52.3	.016	3.64
	July	48.3	43.9	.030	.068	.219	.50	4.4	2.20	50.0	.014	3.18
Lot 4. Corn, Mash B.-milk instead of mash	Nov.	44.9	40.2	.030	.075	.189	.47	4.7	2.56	54.5	.020	4.25
	Dec.	49.3	44.1	.030	.068	.195	.44	5.2	2.69	51.7	.020	3.85
	Jan.	50.2	45.2	.030	.066	.204	.45	5.0	2.62	52.4	.016	3.20
	Feb.	52.5	47.0	.030	.064	.222	.47	5.5	2.84	51.6	.020	3.64
	Mar.	53.1	47.9	.032	.067	.216	.45	5.2	2.69	51.7	.018	3.46
	Apr.	51.5	46.8	.033	.071	.220	.47	4.7	2.41	51.3	.016	3.40
	May	49.3	44.7	.032	.072	.198	.44	4.6	2.35	51.1	.015	3.26
With limestone.	June	52.0	47.3	.032	.068	.236	.50	4.7	2.42	51.5	.018	3.83
	July	50.3	45.2	.034	.075	.231	.51	5.1	2.56	50.2	.017	3.33

Table 17.—Analyses of Carcasses of Hens of all Lots.

Date	Pen No.	Hen No.	Total wt. of hens. Gms.	Wt. of carcass. Gms.	Wt. of CO_2-free ash of carcass. Gms.	CO_2-free ash in carcass. Per cent.	Wt. of CaO in carcass. Gms.	CaO in CO_2-free ash of carcass. Per cent.	Wt. of P_2O_5 in carcass. Gms.	P_2O_5 in CO_2-free ash of carcass. Per cent.
Nov. 1, 1921	Control	A	1280.	721.	23.45	3.25	9.58	40.85	10.18	43.40
Nov. 1, 1921	Control	B	1137.	657.	22.15	3.37	9.57	43.20	9.97	45.01
		Total	2417.	1378.	45.60	6.62	19.15	84.05	20.15	88.41
		Average	1209.	689.	22.80	3.31	9.58	42.03	10.08	44.21
June 1, 1922	Control	C	1025.	630.	21.43	3.40	9.63	44.95	9.43	44.02
June 1, 1922	Control	D	1055.	616.	23.25	3.77	10.51	45.22	10.15	43.65
		Total	2080.	1246.	44.68	7.17	20.14	90.17	19.58	87.67
		Average	1040.	623.	22.34	3.59	10.07	45.09	9.79	43.84
Apr. 20, 1922	1	397*	1345.	788.	22.30	2.83	9.74	43.61	9.57	42.90
May 1 1922		393*	1179.	601.	21.80	3.63	9.85	45.20	9.68	44.40
May 24, 1922		396	1245.	941.	20.69	2.20	9.23	44.61	9.08	43.90
June 1, 1922		390	980.	587.	16.28	2.77	6.49	39.85	7.33	45.01
June 1, 1922		389	1280.	726.	18.51	2.55	7.99	42.65	8.53	46.10
June 1, 1922		398	1239.	730.	19.78	2.71	8.68	43.90	8.76	44.29
		Total	4744.	2984.	75.26	10.23	32.39	171.01	33.70	179.30
		Average	1186.	746.	18.82	2.56	8.10	42.75	8.43	44.83

*Not included in the averages.

Date	Pen No.	Hen No.	Total wt. of hens. Gms.	Wt. of carcass. Gms.	Wt. of CO_2-free ash of carcass. Gms.	CO_2-free ash in carcass. Per cent.	Wt. of CaO in carcass. Gms.	CaO in CO_2-free ash of carcass. Per cent.	Wt. of P_2O_5 in carcass. Gms.	P_2O_5 in CO_2-free ash of carcass. Per cent.
June 1, 1922	2	376	1542.	976.	29.79	3.05	12.78	42.90	13.41	45.00
June 1, 1922		378	1516.	989.	37.50	3.79	16.59	44.25	16.31	45.70
June 1, 1922		379	1560.	982.	32.68	3.33	14.27	43.66	14.74	45.10
June 1, 1922		380	1032.	626.	18.68	2.98	8.44	45.20	8.28	44.30
		Total	5650.	3573.	118.65	13.15	52.08	176.01	52.74	180.10
		Average	1413.	893.	29.66	3.29	13.02	44.00	13.19	45.02
June 1, 1922	3	229	1290.	789.	24.68	3.13	10.76	43.60	11.20	45.40
June 1, 1922		239	1152.	710.	23.32	3.28	9.77	41.90	10.77	46.20
June 1, 1922		250	1319.	849.	28.96	3.41	13.38	46.20	12.39	42.80
June 1, 1922		252	1166.	779.	24.44	3.14	11.21	45.85	10.51	43.00
		Total	4927.	3127.	101.40	12.96	45.12	177.55	44.87	177.40
		Average	1232.	782.	25.35	3.24	11.28	44.39	11.22	44.35
June 1, 1922	4	263	1202.	717.	25.62	3.57	11.17	43.61	11.55	45.10
June 1, 1922		264	1069.	637.	22.91	3.60	9.84	42.95	10.72	46.80
June 1, 1922		273	1172.	733.	19.70	2.69	9.00	45.66	8.70	44.16
June 1, 1922		279	1111.	695.	23.29	3.35	10.91	46.85	10.39	44.60
		Total	4554.	2782.	91.52	13.21	40.92	179.07	41.36	180.66
		Average	1138.	695.	22.88	3.30	10.23	44.77	10.34	45.16

Table 18.—Analyses of Leg Bones of Hens of all Lots.

Date	Pen No.	Hen No.	Total wt. of 4 leg bones.	Wt. of leg bones dried at 100° for 24 hrs.	Wt. of CO_2-free ash.	Per cent CO_2-free ash in dried leg bones.	Wt. of CaO in ash of leg bones.	Per cent CaO in CO_2-free ash of leg bones.	Wt. of P_2O_5 in ash of leg bones.	Per cent P_2O_5 in ash of leg bones.
Nov. 1, 1921	Control	A	27.91	18.19	7.32	40.24	4.02	54.85	3.12	42.60
Nov. 1, 1921	Control	B	25.06	16.12	6.68	41.44	3.68	55.06	2.79	41.75
		Total	52.97	34.31	14.00	81.68	7.70	109.91	5.91	84.35
		Average	26.49	17.16	7.00	40.84	3.85	54.95	2.96	42.18
June 1, 1922	Control	C	26.23	16.09	7.45	46.30	4.04	54.23	3.14	42.09
June 1, 1922	Control	D	28.96	18.03	9.32	51.69	5.13	55.00	3.87	41.52
		Total	55.19	34.12	16.77	97.99	9.17	109.23	7.01	83.61
		Average	27.60	17.06	8.39	49.00	4.59	54.62	3.51	41.81
Apr. 20, 1922	1	397*	27.55	13.21	6.26	47.38	3.42	54.70	2.60	41.55
May 1 1922		393*	26.52	14.11	7.34	52.02	3.97	54.12	3.01	40.99
May 24, 1922	1	396	29.99	14.01	6.68	47.67	3.69	55.20	2.78	41.63
June 1, 1922		390	25.75	11.44	4.79	41.87	2.59	54.07	2.01	41.90
June 1, 1922		389	29.17	14.79	6.95	47.00	3.77	54.25	2.92	42.05
June 1, 1922		398	26.47	11.81	5.98	50.64	3.26	54.54	2.46	41.21
		Total	111.38	52.05	24.40	187.18	13.31	218.06	10.17	166.79
		Average	27.84	13.01	6.10	46.79	3.33	54.51	2.54	41.70

Date	Pen No.	Hen No.	Total wt. of 4 leg bones.	Wt. of leg bones dried at 100° for 24 hrs.	Wt. of CO_2-free ash.	Per cent CO_2-free ash in dried leg bones.	Wt. of CaO in ash of leg bones.	Per cent CaO in CO_2-free ash of leg bones.	Wt. of P_2O_5 in ash of leg bones.	Per cent P_2O_5 in ash of leg bones.
June 1, 1922	2	376	30.70	19.81	10.73	54.01	5.77	53.93	4.36	40.75
June 1, 1922		378	35.19	23.26	12.68	54.56	7.01	55.31	5.21	41.09
June 1, 1922		379	36.76	23.08	12.13	52.55	6.66	54.92	5.07	41.80
June 1, 1922		380	24.24	15.35	6.90	44.95	3.80	55.13	2.85	41.32
		Total	126.89	81.50	42.44	206.07	23.24	219.29	17.49	164.96
		Average	31.72	20.37	10.61	51.52	5.81	54.82	4.37	41.24
June 1, 1922	3	229	30.96	17.97	9.20	51.20	5.05	54.88	3.83	41.62
June 1, 1922		239	25.08	14.29	8.57	59.97	4.61	53.75	3.51	40.95
June 1, 1922		250	29.94	18.14	9.50	52.37	5.26	55.42	3.92	41.30
June 1, 1922		252	25.12	14.73	7.51	50.99	4.10	54.62	3.15	42.00
		Total	111.10	65.13	34.78	214.53	19.02	218.67	14.41	165.87
		Average	27.77	16.28	8.69	53.63	4.75	54.67	3.60	41.47
June 1, 1922	4	263	33.42	23.83	12.79	54.97	7.24	55.30	5.37	41.00
June 1, 1922		264	31.48	21.33	10.11	43.29	5.60	55.46	4.16	41.20
June 1, 1922		273	26.71	15.97	7.17	44.90	7.64	54.82	5.84	41.85
June 1, 1922		279	29.75	19.95	10.46	52.43	5.72	54.66	4.28	40.90
		Total	121.36	81.08	40.53	195.59	26.20	220.24	19.65	164.95
		Average	30.34	20.27	10.13	48.90	6.55	55.06	4.91	41.24

*Not included in the averages.